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Quality characteristics of white cabbage juice stored using thermal processing and addition of chemical additives

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Abstract: Cabbage (*Brassica oleracea L*. var. *capitata*) is one of the most important vegetables grown worldwide. Cabbage is valued for medicinal purposes in treating headaches, gout, diarrhea and peptic ulcers. The beneficial phytochemicals in cabbage help to activate and stabilize the body's antioxidant and detoxification mechanisms that dismantle and eliminate cancer-producing substances. This seasonal vegetable can be made available for the consumers in off seasons also in the form of juice. The juice can be made shelf stable by using thermal treatment and various chemical additives. Therefore, the aim of the experiment was to compare the effect of different chemical additives namely Sodium benzoate, Potassium metabisulfite (KMS) and their combinations and the heat treatment, on the physicochemical, phytochemical parameters and antioxidant activity of Cabbage juice for a period of 6 months at room temperature at the regular intervals.The parameters like TS and TSS did not change significantly. The minimum increase in acidity was found in samples treated with combination of Sodium benzoate and Potassium metabisulfite. The color was best preserved by addition of KMS where the L value changed from 52.66 to 50.86 after 6 months. The ascorbic acid, total phenol content and antioxidant activity was best preserved by KMS with final values of 2.51 mg/100 g,21.18 mg/100 g and 15.97 % respectively that were far better than the thermally treated samples with values 1.47 mg/100 g, 8.14 mg/100 g and 6.98 % respectively. Keeping in view all the parameters KMS was found to be the most appropriate agent for preservation.

Keywords: Antioxidant activity, Cabbage, Phytochemicals, Storage

INTRODUCTION

Cabbage (*Brassica oleracea L*. var. *capitata*), ashallow -rooted, cool season crop is one of the most important vegetables grown worldwide. It belongs to the family Cruciferae, which includes Brussels sprouts, broccoli, cauliflower and kale. Cabbage is consumed either raw or processed in different ways, e.g., boiled or, fermented or, used in salads. Fresh cabbage juice, prepared either separately or mixed with other vegetables such as carrot and celery, is often included in many commercial weight-loss diets (Samec *et al.*, 2011). Due to its anti-inflammatory and antibacterial properties, cabbage has widespread use in traditional medicine, in alleviation of symptoms associated with gastrointestinal disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome) as well as in treatment of minor cuts and wounds and mastitis, improve the bioavailable content of nonheme iron (Chiplonkar *et al.,* 1999). Cabbage is good detoxifier, which purifies blood and removes toxinsdue to the presence of vitamin C and sulphur (Tang *et al*., (2007) in good amount. The beneficial phytochemicals in cabbage help activate and stabilize the body's antioxidant and detoxification mechanisms that dismantle and eliminate cancer-producing substances (Brooks *et al*., 2001). Epidemiological data as well as in vitro studies strongly suggest that vegetables having antioxidant phytochemicals have strong protective effects against major degenerative diseases including cancer and cardiovascular diseases (Block *et al*., 1992). The protective action of cruciferous vegetables has been attributed to the presence of antioxidant phytochemicals, (Prior and Cao, 2000). Interest in the role of free radical scavenging-antioxidants in human health has prompted research in the fields of horticulture and food science to assess the antioxidant phytochemicals in fruits and vegetables. During the harvesting season, large quantities get spoiled due to excess production. So a Long term preservation method is required that could be useful to prevent spoilage of cabbage such that it could be consumed in off seasons as well. For such reasons, cabbage can be processed into a shelf stable juice. Some studies have been conducted to quantify the physicochemical, phytochemical and antioxidant activity of cabbage and members of this family, so far, there has not been a systematic study on the effect of chemical additives or preservatives on the shelf life of processed cabbage juice. Keeping in view, the present study was conducted to process and preserve the cabbage juice acceptable of a longer period of time.

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MATERIALS AND METHODS

Raw materials: The study was conducted in the Department of Food Science and Technology, Punjab Agricultural University, Ludhiana. Cabbage was procured from the Department of Vegetable Science, Punjab Agricultural University, Ludhiana.

Extraction process of cabbage juice: Fresh cabbages were washed thoroughly and cut off from the top and were not peeled. The Cabbage juice was extracted in a juicer extractor (Kalsi: 9001-2008). The juice was pasteurized at 83 °C for 3 min and citric acid @ 0.15 % was added, followed by chemical preservatives.

Dose distribution of chemical additives:

Sample	Chemical additives	Dose (ppm)
T_2	Na-benzoate	3000
T_3	KMS	3000
T_4	Na-benzoate+ KMS	1500+1500

The pre-sterilized glass bottles were filled with the hot juice and corked. T_1 sample was given the pasteurization treatment followed by processing at 100 °C for 20 min in boiling water bath and gradually cooled to a low temperature under running tap water. These processed juices were kept for storage at room temperature for six months.

Physico-chemical analysis: Cabbage juices were analysed at regular interval of one month for the parameters like Total solids**,** Titratable acidity using AOAC (2000) methods. TSS was taken using hand refractometer (ERMA, Japan), color using Minolta Hunter colorimeter.

Phytochemical analysis: For phytochemical parameters, Vitamin C was determined by the titrimetric method using dichlorophenol indophenol dye (Ranganna, 1986). Total phenolic content was determined by Folin-ciocalteau reagent (Singleton and Rossi, 1965). A standard curve was plotted by taking known amount of Gallic acid as reference standard and concentration was calculated from the standard curve. The % Antioxidant activity was determined by DPPH (2, 2-diphenyl-2-picrylhydrazyl) method (Brand-Williams *et al*., 1995). Methanolic extract of sample was taken for antioxidant activity analysis and calculated according to the following formula. BHT was taken as a standard at a fixed concentration of 5 mg/ml.

$$\% \text{ AA} = \frac{\text{Control OD(0 min)} - \text{Sample OD(30 min)}}{\text{Control OD (0 min)}} \times 100$$

The samples were studied for the effect of different chemical additives on physicochemical [TS, TSS, acidity, color (L, a, b)], phytochemical (ascorbic acid, total phenols) and % antioxidant activity for the storage period of 6 months.

Statistical analysis: The results were evaluated by Analysis of Variance (ANOVA) and Tukey's post hoc tests using Systat statistical program version 16 (SPSS Inc., USA).

RESULTS AND DISCUSSION

Effect on total solids and TSS: TS increased non-significantly ($p \leq 0.05$) in all the juices of cabbage dur-

Table 1. Effect of storage period and treatments on titratable acidity (%) of cabbage juice**.**

Treatments	Storage months						
	0	1	2	3	4	5	6
T1	0.341^{aB}	0.378^{aB}	0.401^{aB}	0.425^{aC}	0.467^{aB}	0.504^{aB}	0.584^{aBC}
T2	0.373^{aA}	0.405^{aA}	0.439^{aA}	0.483^{aA}	0.519^{aA}	0.551^{aA}	0.586^{aA}
T3	0.373^{aA}	0.392^{aAB}	0.423^{aAB}	0.456^{aB}	0.481^{aB}	0.506^{aB}	0.549^{aB}
T4	0.373^{aA}	0.392^{aAB}	0.415^{aAB}	0.442^{aBC}	0.475^{aAB}	0.496^{aB}	0.516^{aC}

* Data is expressed as means of 3 readings and values followed by different upper case or lower case letters are significantly different ($p \leq 0.05$) within columns and rows respectively.

Table 2. Effect of storage period and treatments on the color values (L a b) of cabbage juice**.**

Treatments		Storage months						
		0	1	2	3	4	5	6
L	T1	44.67^{aC}	44.12^{aC}	43.77^{abC}	43.16^{abD}	42.43^{abcD}	41.64^{bcD}	40.55^{cD}
	T2	47.83^{aB}	47.19^{abB}	46.54^{abcB}	46.02^{abcC}	45.67^{abcC}	44.92^{bcC}	44.12^{cC}
	T3	52.66^{aA}	52.39^{aA}	52.07^{aA}	51.83^{aA}	51.52^{aA}	51.28^{aA}	50.86^{aA}
	T4	50.71^{aA}	50.32^{aA}	49.96^{abA}	49.47^{abB}	48.87^{abB}	48.27^{abB}	47.57^{bB}
A	T1	0.28^{dA}	0.32^{cdA}	0.39^{bcdA}	0.46^{abcdA}	0.51^{abcA}	0.57^{abA}	0.63^{aA}
	T2	0.33^{bAB}	0.35^{bAB}	0.38^{abA}	0.42^{abA}	0.47^{abA}	0.51^{abA}	0.58^{aA}
	T3	0.23^{cAB}	0.26^{bcAB}	0.3^{bcAB}	0.35^{abcAB}	0.42^{abcA}	0.48^{abA}	0.55^{aA}
	T4	0.12^{aB}	0.13^{aB}	0.15^{aA}	0.18^{aB}	0.21^{aB}	0.25^{abB}	0.29^{aB}
B	T1	-0.02^{aB}	-0.04^{abB}	-0.08^{abB}	-0.12^{abB}	-0.16^{abB}	-0.21^{abB}	-0.25^{bB}
	T2	0.19^{aA}	0.17^{aA}	0.15^{aA}	0.12^{aA}	0.09^{aA}	0.06^{aA}	0.02^{aA}
	T3	0.03^{aAB}	0.02^{aAB}	0.01^{aAB}	-0.02^{aAB}	-0.04^{aAB}	-0.07^{aAB}	-0.1^{aAB}
	T4	0.11^{aAB}	0.1^{aAB}	0.08^{aAB}	0.05^{aAB}	0.02^{aAB}	-0.01^{aAB}	-0.03^{aAB}

* Data is expressed as means of 3 readings and values followed by different upper case or lower case letters are significantly different ($p \leq 0.05$) within columns and rows respectively.

Table 3. Effect of storage period and treatments on ascorbic acid content (mg/100g) of cabbage juice.

Treatments	Storage months						
	0	1	2	3	4	5	6
T1	6.98^{aA}	6.43^{aA}	5.46^{abA}	4.21^{bcA}	3.95^{bcA}	2.69^{cdA}	1.47^{dA}
T2	7.75^{aA}	7.52^{aA}	6.29^{abA}	5.11^{bcA}	4.89^{bcA}	3.62^{cdA}	2.38^{eA}
T3	7.75^{aA}	7.56^{abA}	6.68^{abcA}	5.57^{bcdA}	4.86^{cdA}	3.75^{deA}	2.51^{eA}
T4	7.75^{aA}	7.59^{aA}	6.61^{abA}	5.72^{abcA}	4.63^{bcdA}	3.86^{cdA}	2.49^{dA}

* Data is expressed as means of 3 readings and values followed by different upper case or lower case letters are significantly different ($p \le 0.05$) within columns and rows respectively.

Table 4. Effect of storage period and treatments on total phenols (mg/100g) of cabbage juice.

Treatments	Storage months						
	0	1	2	3	4	5	6
T1	25.41^{aA}	23.85^{aA}	21.64^{abA}	18.14^{abA}	15.76^{abA}	12.62^{abA}	8.14^{bA}
T2	34.76^{aA}	32.17^{aA}	29.61^{abA}	26.29^{abA}	23.82^{abA}	20.96^{abA}	16.79^{bA}
T3	35.11^{aA}	33.79^{aA}	31.17^{abA}	29.62^{abA}	27.19^{abA}	24.76^{abA}	21.18^{bA}
T4	35.72^{aA}	33.88^{aA}	31.79^{abA}	28.96^{abA}	26.64^{abA}	23.85^{abA}	19.27^{bA}

* Data is expressed as means of 3 readings and values followed by different upper case or lower case letters are significantly different ($p \le 0.05$) within columns and rows respectively.

Table 5. Effect of storage period and treatments on % antioxidant activity of cabbage juice**.**

Treatments	Storage months						
	0	1	2	3	4	5	6
T1	22.81^{aB}	20.37^{abB}	18.87^{abB}	15.49^{bcB}	12.08^{cdB}	9.76^{deB}	6.98^{eB}
T2	27.63^{aA}	25.59^{abA}	23.96^{abcA}	21.52^{bcdA}	19.21^{cdA}	16.87^{deA}	13.26^{eA}
T3	28.55^{aA}	26.02^{abA}	24.59^{abcA}	22.17^{bcdA}	20.85^{cdeA}	18.49^{deA}	15.97^{eA}
T4	28.08^{aA}	26.16^{abA}	24.71^{abcA}	22.46^{bcdA}	20.12^{cdA}	17.73^{deA}	14.24^{eA}

* Data is expressed as means of 3 readings and values followed by different upper case or lower case letters are significantly different ($p \le 0.05$) within columns and rows respectively.

ing the storage. On the day of preparation, the amount % of TS in sample T1, T2, T3, T4 were 14.28, 13.66, 14.45 and 14.87 respectively. At the end of 6 months, the TS in the samples increased to 16.44, 14.88, 15.51 and 15.81 respectively. The % TSS values of samples T_1 to T_4 on day first was 7.4 for each sample which gradually increased to 7.7, 7.6, 7.5 and 7.5 respectively after 6 months of storage. Although TSS increased for all the samples but the changes were non-significant ($p \le 0.05$). An increase in soluble content of apple pulp was reported during storage when preserved with chemical preservatives. Preservatives like sodium benzoate , potassium metabisulphite and citric acid in various combinations (Durrani *et al*., 2010). The treatments had no significant effect ($p \le 0.05$) on total solids as well as TSS.

Effect on acidity: The chemical additives as well as storage had no significant effect ($p \le 0.05$) on acidity of the cabbage juice. The titratable % acidity of sample T_1 on day first was found to be 0.341 and 0.373 for the three chemically treated samples(T_1 to T_3) that gradually increased to 0.584, 0.586, 0.549 and 0.516 respectively (Table 1). The similar pattern in increase in titratable acidity was found during storageof Jamun RTS beverages for a period of 3 months (Kesharwani *et al*., 2015). Also, in another study, the percentage of titrable acidity significantly increased from the day of preparation (0.276 %) to 90 days of storage (0.299 %) in a study for preparation of blended beverages by utilizing jamun juice (Priyanka *et al*., 2015).In present study, the acidity of the thermally treated sample (T_1) increased more as compared to other chemically treated samples and the change was least in T_4 sample**.**

Effect on color (L a b values): Color is one of the most important visual attributes for juices. The values for color varied significantly ($p \le 0.05$), both for storage as well as chemical treatments. On the day of preparation, the lightest sample was T_3 followed by T_4, T_2 and T_1. At the end of 6 months, T_3 remained the lightest and T_2 was found dull than the other samples. The 'a' value decreased significantly ($p \le 0.05$), but in terms of greenness, T_4 was found to be the greenest and retained the maximum greenness than the other 3 samples at the end of 6 months (Table 2). These results corroborated with that of Deka *et al*., (2005), who found the decrease in hunter color values 'L' and 'a' over a storage period of 6 months. The b values were highest for T_2 and lowest for T_1 and results after 6 months of storage, remained the same for all the samples. On the whole, sample T_2 with Sodium benzoate retained the best color of all the 4 samples. Tomato juice with Na benzoate seems to be more stable than the other preservatives during 6 months of storage and developed lesser off color and turbidity (Hossain *et al*., 2011).

Effect on vitamin C content: Vitamin C is light and heat sensitive, the concentration of Vitamin C follows first order kinetics and thus storage time affects Vitamin C content (Heldman and Singh, 1981). According to the results, chemical additives have significant effect ($p \leq 0.05$) on Vitamin C content of cabbage juice. Also the Vitamin C content decreased significantly ($p \leq 0.05$) during the storage. On the day of preparation, Vitamin C content in samples T_1, T_2, T_3 and T_4 was 6.98, 7.75, 7.75 and 7.75 mg/100 g respectively. The values came out to be lower in T_1 as heat treatment destroys Vitamin C. This difference in reduction rate of ascorbic acid, a heat sensitive vitamin, may be due to longer exposure time of juice blends to high temperatures (Calskantur *et al.,* 2011). At the end of 6 months, the Vitamin C content reduced to 1.47, 2.38, 2.51 and 2.49 mg/100g respectively (Table 3). Out of the chemically treated samples, potassium metabisulphite

retained the maximum Vitamin C. The application of KMS reduces the loss of ascorbic acid during the storage of leafy vegetables (Negi and Roy, 2000). Also, in a study conducted by Bal *et al.,* (2014), ascorbic acid of guava nectar decreased significantly during the entire storage period of nine months. This reduction might be due to oxidation of ascorbic acid into dehydroascorbic acid by oxygen. These losses of ascorbic acid were attributed to the effect of processing, storage time and exposure to light.

Effect on total phenols: The total phenolic content in samples T_1 to T_4 on the first day was 25.41, 34.76, 35.11 and 35.72 mg/100g respectively. The added chemicals preserved the phenolic content more than thermally treated sample (T_1). But both the treatments and storage affected the total phenols non-significantly ($p \leq 0.05$). At the end of 6 months, the Total phenolic content came out to be 8.14, 16.79, 21.18 and 19.27 mg/100g respectively (Table 4). According to the findings, a decrease in total polyphenol content of tomato juices after 3, 6 and 9 months of storage were reported (Vallverdu-Queralt *et al.* 2011). Mgaya-Kilima *et al.*, (2014) concluded a decrease in total phenolic compounds of roselle fruit juice blends stored at 28 °C for 6 months. The decrease in polyphenols could mainly be resulted from oxidation of these compounds and polymerization with proteins (Liu *et al.,* 2014). The decrease was found to be least in sample T_3, followed by T_4 and T_2.

Effect on antioxidant activity: Antioxidants delay the oxidation process, inhibiting the polymerization chain initiated by free radicals and other subsequent oxidizing reactions (Halliwell and Aruoma, 1991). According to the results, on the day of preparation, percent Antioxidant activity for samples T_1 to T_4 was found to be 22.81, 27.63, 28.55, 28.08 mg/100g respectively (Table 5). Significant ($p \leq 0.05$) decrease in antioxidant activity was found in treatments and also during storage months. At the end of 6 months, the percent antioxidant activity decreased to 6.98, 13.26, 15.97 and 14.24 percent respectively. However, the decrease was found to be least in sample T_3. It has been reported that the decrease in antioxidant activity may be linked to a decrease in total phenolic content and vitamin C during storage (Klimczak *et al*., 2007). According to them, antioxidant activity of orange juices decreased by 45 percent after 6 months of storage at 28 °C. The results of the current investigation are in line with Saci *et al.,* (2015) where the antioxidant activity of carrot and mango beverages decreased significantly after 90 days storage at ambient temperatures. However, in case of cabbage, the vitamin content is relatively high. So the reduction of antioxidant activity is mainly associated with significant decrease in vitamin content.

Conclusion

It was concluded that potassium metabisulphite proved to be a better preservative than Na-benzoate and their combination for the stability of physicochemical and phytochemical parameters and maintaining the antioxidant activity of the cabbage juice.

In present study, the results for the investigation to find the best treatment for preservation of cabbage juice showed that there were insignificant changes in TS and TSS during the storage. The minimum increase in pH was found in the sample treated with both sodium benzoate and Potassium metabisulphite where the value increased from 0.373 % to 0.516 % on storage of 6 months. For the parameters like color (L), ascorbic acid, total phenols and % antioxidant activity, potassium metabisulphite proved to be a better preservative than Na-benzoate and their combination as well as the thermal treatments with the final values of 50.86, 2.51 mg/100 g,21.18 mg/100 g and 15.97 % respectively. Hence, this method of preservation can provide opportunity to farmers facing glut for their crop in the market during season thus reducing the post harvest losses and significantly contributing to the food industry.

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